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I, KIM MARSHALL, MANAGER EXAMINATION SUPPORT AND SALES, hereby certify that the annexed is a true copy of the Provisional specification in connection with Application No. PP 2907 for a patent by GLENBORDEN PTY LTD. and SUNICOVE PTY LTD., filed on 9 April 1998.

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KIM MARSHALL
MANAGER EXAMINATION SUPPORT AND SALES

AUSTRALIA

Patents Act 1990

ORIGINAL

PROVISIONAL SPECIFICATION

DIAPHRAGM REGULATOR

The invention is described in the following statement:

DIAPHRAGM REGULATOR

FIELD

The present invention relates to fluid regulators, the regulation of pressure and/or fluid flow in general and the parts therefore.

CROSS REFERENCE

Reference is made to co-pending applications entitled Fluid Regulator for an Aerosol, Fluid Regulator for a Trigger Pump and 2 Part Regulator, filed on the same day by the present applicant, and hereinafter referred to respectively as Aerosol Application, Trigger Pump Application and 2 Part Application. The disclosure of these applications is incorporated herein by reference.

BACKGROUND

Pressure regulators typically incorporate several parts working together. Each part serves a particular purpose and therefore requires certain properties. Pressure regulators usually include a means of converting pressure changes into movement, such as a partition having an area open to pressure which is converted to a force; a biasing means such as a spring which moves relative to the force; a flow regulating device such as a valve; and a connection between the partition and valve. An example given in US patent No. 5035260 and shown in Figure 1 of that patent is described below.

In figure 1 of the above US patent, there is shown a line pressure regulator for a nozzle 10. The line pressure regulator comprises a housing 11 having an inlet 13 which opens into a first chamber 14 accommodated within the tubular body 12. The walls of the first chamber 14 are formed with a first port 15 and second port 16. The first port 15 opens to one side of a second chamber 18, while the second port 16 opens to another side of the second chamber 18 which in turn opens to the outlet 17 in the tubular body 12. Both sides of the second chamber 18 communicate through a fluid passageway 19 which provides a relatively unrestricted flow path. A spindle like support element 20 is received within the tubular housing such that it is axially slidable through the ports 15 and 16. The support element 20 supports a set of three valve members 21, 22, and 23 which are associated with the first, second and third ports 15, 16 and 24 respectively. The first valve 21 and second valve 22 are dimensioned so

that they are slidably receivable through the first port 15 and second port 16 respectively with a very close tolerance therebetween. The end of the support element 20 adjacent the outlet 17 supports a valve member 23 which is sealingly engageable with a valve seat provided at the third port 24 when the support element 20 is located at an end position, at which position the line regulator is closed. The other end of the support element 20 is provided with an enlarged disc like head which is connected to a collapsible closure 26 extending between the periphery of the head 25 and a stop member 27 provided at the end of the tubular body 12. A pressure spring 28 is accommodated within the collapsible closure 26 between the face of the enlarged head remote from the other port 16, and the stop member 27. The stop member 27 is provided with a threaded stud 29 which bears against the end of the pressure spring adjacent the stop 27. The extent of the penetration of the stud into the stop 27 serves to vary the extent of the biasing force applied to the support element 20 by the spring 28. A portion of the support element adjacent the enlarged head 25 is formed with an increased diameter shank 30 which is snugly and slidably received by the flutes in the port 16 when the support element 20 is in its end position at which position the third valve member is in engagement with the third ports.

When no fluid pressure is applied to the inlet 13 and the pressure is insufficient to overcome the biasing force provided by the spring 28, the biasing force of the spring 28 ensures engagement of the third valve member 23 with the third port 24 to close the line regulator and prevent any fluid flow through the line regulator. On application of sufficient fluid pressure an axial force is exerted on the enlarged head member 25 adjacent the port 16 in opposition to the biasing force provided by the spring 28, and because the valve member 23 is smaller than the enlarged head member 25 the support element 20 is caused to move axially within the housing and the third valve member 23 disengages from the third port 24, allowing fluid to flow from the outlet. The commencement of fluid flow reduces the pressure on the enlarged head and balances the biasing force from the pressure spring 28. Should there be a rise in inlet pressure the degree of engagement increases thereby increasing throttling.

Partitions used in these pressure regulators have been made from materials such as rubber, which deforms easily and provides an effective seal against fluid leakage. The spring is normally a metal such as steel, which is resilient and has well known and repeatable deformation characteristics and is usually in the form of a coil spring. The partition covers the spring in such a way that when the pressure on the partition and support member increases, the spring and partition deflect. The rubber used in the partition is usually thin, as it is desirable that the spring characteristics should only come from the spring, not a combination of the spring and partition which may produce unpredictable or non-repeatable deformations.

Known types of pressure regulators usually need to handle corrosive fluids and have not been able to be constructed from a single type of material, as the requirements of the various parts were such that an appropriate material could not be found. As an example, the biasing, or initial pre-tensioning force of the spring required that the spring material not be subject to appreciable creep, and therefore a metal such as steel was required. The partition seals against the housing of the regulator, requiring a soft material such as rubber. The valves need to be stiff enough to seal against the valve seats in the housing, but also needed to be easily constructed, therefore a hard plastics material has been used. The different requirements for the materials resulted in many different parts being used to construct in-line regulators, increasing the manufacturing costs and requiring the further step of multi-part assembly. Further, as the housing is typically a plastics material, there are limitations on the methods that can be used to attach the various materials to the housing.

If a small regulator was desired, for example, for use in an aerosol actuator, the parts needed to construct the regulator are very small, resulting in significant manufacturing and assembly problems.

Despite the ease of showing various springs and spindles in a drawing, the reality of manufacturing such components for use in, say aerosol actuators, and thus the requirement for miniaturisation, creates great problems for mass production. In aerosol containers in particular, it is desirable to have the pressure regulator fit into the actuator behind the spray nozzle and adjacent the

inlet. The regulator is therefore required to be very small, and the movement of the valves and partition to also be very small, typically less than 1 mm. The configuration of existing pressure regulators does not allow for easy miniaturisation as some parts cannot be shrunk proportionally and still function correctly, such as the spring and the partition. For example, due to the pressures to be regulated, there is a minimum thickness that the partition can be before it is susceptible to bursting.

As can be seen from the above, regulators are not easily transferable for use in an aerosol actuator as their shape is not appropriate.

SUMMARY OF THE INVENTION

The present invention has as an object to alleviate at least one prior art problem as outlined above.

Accordingly, the present invention relates to a spring diaphragm which may be used in a fluid regulator. The use of a spring diaphragm leads to a reduction in the number of parts of the regulator, giving benefits such as a reduction in manufacturing costs, and/or in overall size of the regulator. Also, using of a spring diaphragm removes the need for a separate helical spring and allows a single material to be used for the spring and diaphragm function.

Desirably, the fluid regulator as disclosed above has an inlet chamber and an outlet chamber, wherein at least one valve is attached to a spindle and is situated adjacent at least one corresponding port in the inlet chamber to restrict flow to the outlet chamber, such that there is minimal net force on the valve(s) from the inlet pressure of the fluid. The arrangement of the valves in the ports, such that there is minimal net force on the spindle, allows the removal of the spring biasing force if desired. The diaphragm may then be made from the same materials as the spindle and valves, such as a plastics material. Thus all the internal parts of the fluid regulator may be made of the same material.

The present invention also relates to a method of regulating fluid flow by adjusting the clearance between at least one valve and corresponding port wherein the clearance between the valve and port is adjusted by a spring diaphragm having predetermined resilient characteristics. This leads to the removal of the spring, enabling the regulator to be made with fewer parts and to

occupy smaller volume. Regulation may also be influenced by the shape or design of the diaphragm, such as slots or grooves for weakening and/or ridges or ribs for stiffening.

Preferably, one side of the spring diaphragm is exposed to the outlet pressure of the regulator and the other side is open to the atmosphere.

Typically the spring diaphragm is sealingly attached to a housing of the regulator. This prevents the unwanted leakage of fluid from the housing. This may be accomplished, for example, by an interference fit, glue, ultrasonic welding or other appropriate methods. The diaphragm may then be assembled quickly and easily in a way compatible with mass production of the regulators.

In another form, the present invention resides in a fluid regulator having a spring diaphragm which is substantially free of biasing force when no fluid is flowing. This allows the diaphragm to be free of the effects of creep, as there are no forces acting on the diaphragm for extended periods.

Preferably, the spring diaphragm described in the invention above has resilient properties. The diaphragm should be able to return to or near its original position after a short exposure to high pressure once the outlet pressure has returned to atmospheric, without appreciable permanent deformation or creep. When the fluid is flowing, the resilient properties of the diaphragm provide a force which counteracts the force across the diaphragm from the outlet pressure. The opposing forces position the diaphragm in such a position that one or more valves connected to the diaphragm by a spindle regulate the flow of fluid from the outlet. The time spent when fluid is flowing from, for example, an aerosol nozzle, is typically quite short, and therefore a material which exhibits creep under extended exposure to stress can still be used.

In one embodiment the fluid regulator, has a spring diaphragm and a spindle supporting one or more valve members of unitary construction. This allows the fluid regulator to be made with much fewer parts, thus enabling the regulator to be made smaller, as well as reducing manufacturing and assembly costs.

Preferably, the spring diaphragm is constructed from the same material as the valves and spindle. This obviously reduces material and manufacturing

costs, while reducing assembly costs.

In another form of the present invention, a spring diaphragm may be attached to a housing of a fluid regulator via a collar situated at the outer periphery of the spring diaphragm. The use of a collar having an interference fit allows the spring diaphragm to be located in a sealing manner within the interior of the housing. This is relatively inexpensive and easy way to fix the spring diaphragm, however, without the collar, an interference fit would cause the spring diaphragm to deflect in the housing, thus effecting the position of the diaphragm in the housing and changing its deflection properties, effectively giving the diaphragm a preload.

Preferably, the collar has an outer surface which extends perpendicularly from the plane of the diaphragm, and a portion projecting from the collar which may be adapted to fit into a corresponding indentation in the housing, wherein the projecting portion is spaced laterally from the spring diaphragm which covers the interior of the collar. This arrangement allows the area of interference, ie the extending portion, to be spaced from the portion surrounding the spring diaphragm. This allows the portion surrounding the spring diaphragm to be substantially stress free and therefore removes any preloading on the spring diaphragm.

The spring diaphragm may be in the form of a membrane such as a plate and optionally may include a number of annular or radial grooves. These grooves can be used to set the stiffness of the diaphragm and therefore control the deflection of the diaphragm for a given pressure regulation range.

Alternatively the diaphragm may have a rippled surface.

The design of the surface of the diaphragm is determined by a number of factors including stiffness, strength, pressure differentials etc.

In the present application the term fluid regulator is defined to mean an apparatus for the regulation or control of fluid flow, flow rate and/or pressure of flow.

PREFERRED EMBODIMENT

One of the preferred embodiments of the present invention will now be described with reference to the accompanying diagrams, wherein:

Fig 1 is a sectional side view of an aerosol actuator incorporating a fluid regulator of the present invention;

Fig 2 is a sectional side view of a second embodiment incorporating the present invention;

Fig 3a-3g are views of several embodiments of spring diaphragms in accordance with the present invention;

Fig 4 is a graph of force compared to deflection of a typical bellville type spring diaphragm showing the regulating range for the present invention;

It is desirable to regulate the outlet pressure of, for example, an aerosol container in order to obtain consistent results in terms of flow rate or outlet pressure. This is particularly important for containers using pressurised gases such as air or nitrogen where a full container is highly pressurised to start and drops significantly as the container is emptied. Existing aerosol containers normally contain a propellant such as hydrocarbon, which liquefies at moderate pressure. This type of propellant provides a relatively constant internal pressure inside the container as the propellant evaporates, however hydrocarbons are not desirable as propellants for many reasons. Accordingly, a preferred embodiment of a pressure regulator in accordance with the present invention is described below.

A fluid regulator 10 is shown in fig 1. The regulator 10 includes a housing 12, an inlet 14, and an outlet 16. The inlet 14 is connected to the outlet 16 via ports 20 and 22 which communicate with chambers 24 and 26 respectively. Chamber 24 is connected to chamber 26 by a passage 30, and chamber 26 is adjacent outlet 16, allowing fluid to flow in a controlled way from the inlet 14, to the outlet 16.

Situated in the ports 20 and 22 is a support member such as spindle 32. The spindle 32 has valves 34 and 36 which fit into ports 20 and 22 respectively. The valves 34 and 36 have flutes 35 situated on the spindle 32 so that fluid may pass through the ports and the spindle 32 is supported by the ports. The end of the spindle 32 is connected to a spring diaphragm 40 by a ball 42 and socket 44 arrangement. It should be realised that the method of connection of the spindle to the diaphragm is not important to the present invention and any suitable

method of attachment may be employed. Further the spring diaphragm 40 and spindle 32 may be of unitary construction enabling the combined structure to be formed from, for example, injection moulding, from a single material, such as a suitable plastics material.

As fluid enters the inlet 14 and flows past the valves 34 and 36 through the ports 20 and 22, the pressure in the chambers 24 and 26 builds up and acts on the diaphragm 40, causing the spring diaphragm 40 to move laterally, moving the spindle 32 laterally with it. The movement of the spindle 32 causes the valves to move into the ports 20 and 22 thus reducing the flow of fluid through the ports, and reducing the pressure in the chambers 24 and 26. This reduces the pressure on the spring diaphragm 40 and causes the spindle 32 to retract increasing the clearance between the valves and the ports until an equilibrium position is established wherein the pressure from the fluid flow on the face of the spring diaphragm 40 matches the designed spring force acting against the pressure.

The spring diaphragm 40 combines the sealing and partitioning qualities of the prior art, with resilient qualities that were usually imparted by a coil spring. The combination of the separate spring and partition reduces part numbers and overall size of the components, especially as coil springs require a large working volume compared to a spring diaphragm. The spring diaphragm of the present invention has the added advantage that the spring rate is high and therefore the movement of the diaphragm from one pressure extreme to another is quite small, which is desirable in the present invention. This will be discussed in depth below.

The spring diaphragm 40 is shown in figure 1 in a condition where no fluid is flowing. The spring diaphragm is attached to the spindle 32 upon which the valves are located. The pressure on the spring diaphragm 40 adjusts the clearance between the valves and the ports to regulate the flow of fluid. As the fluid starts to flow the valves move toward the ports, (away from the outlet 16) and reduce the clearance. The resilient nature of the spring diaphragm 40 counteracts the force on the face of the spring diaphragm 40 to a certain degree so that flow from the ports is regulated.

After flow from the inlet has been stopped, the spring diaphragm returns to its original position.

As shown in figure 1 the spring diaphragm may be attached to the spindle 32 by a ball and socket arrangement. Alternatively, the spindle 32 including the valves and support flutes can be made integral with the spring diaphragm as seen in the spindle diaphragm member 110 in figure 2. This is particularly important if it is desirable to make these parts from a single material, such as a plastics material. Given the properties required of the spring diaphragm and spindle, a plastics material such as acetal has been found to be suitable.

The spring diaphragm may be attached to the housing in a number of ways. Advantageously the spring diaphragm is sealingly attached to the housing. To assist in the seal between the housing 12 and the spring diaphragm, a collar 150 is provided as shown in figure 2, or collar 50 in figure 1. The collar acts to greatly increase the contact surface area between the spindle diaphragm and the housing, which increases the resistance to fluid leakage. Sealing means such as glue, ultrasonic welding or other appropriate methods may also be employed if desired.

A problem which has been encountered is that the use of an interference fit for attaching a diaphragm to the housing 12 places pressure on the diaphragm effecting its spring properties. Surprisingly, it has been found that if a collar which extends perpendicularly to the diaphragm as shown in figure 2 is used, the main region of interference, and therefore deformation of the collar 150, is moved laterally to be remote from the plane of the spring diaphragm 110. An interference fit can then be used without incurring the preloading or deformation problems of the collar 150. This arrangement allows the spring diaphragm 110 to be attached to the housing 12 without effecting the properties of the spring diaphragm 110.

Different embodiments of spring diaphragms are shown in figures 3a-3g. The spring diaphragm can be described as a plate with various modifying features. In this specification, the term plate is taken to encompass any flat, dished or curved section which may include any number of grooved or rippled forms on the surfaces of the diaphragm. The material that the plate may be

constructed from is preferably a plastics material, but may be any suitable material such as a hard rubber, or thin metal.

An example embodiment of the present invention is discussed in co-pending Application titled Fluid Regulator for an Aerosol filed on even date by the same applicant, and hereby incorporated by reference.

The arrangement of the spring diaphragm depends on the shape, profile and materials used in its construction, as shown in figures 3a-3g. The grooves employed can be used to concentrate forces in localised areas, to increase the flexibility without exceeding the elastics limits of the material being used.

Referring to figures 3a-3g, several different embodiments of an aspect of the present invention are shown. In figure 3a, a spring diaphragm 130 is shown, integrally attached to the spindle 20 and having a collar 140. Given a predetermined pressure and displacement range for a material, the thickness T_1 of the spring diaphragm can be calculated. In spring diaphragm 130, the thickness of the diaphragm is uniform however thickness need not be uniform in all embodiments.

In order to increase displacement when the diaphragm is subjected to a given pressure, an area of reduced strength can be incorporated. This area of reduced strength can take many forms, for example using one or more annular grooves providing localised areas of reduced thickness, as shown at 141 in figure 3b and 138 in figure 3f. The areas of reduced thickness may also be in the form of radial grooves as shown at 143 in figure 3d.

An additional embodiment shown in figure 3c has a rippled spring diaphragm which may be of uniform thickness, or may include some of the weakened areas shown in the other embodiments. The ripples 142 in the surface allow the diaphragm to have an increased lateral deflection for a given pressure differential.

A further embodiment of the spring diaphragm, is based upon a bellville spring with characteristics as shown in figure 4. The bellville spring is stable until it is deflected beyond its flat profile after which it assumes an inverted rest profile. Initially when the outlet pressure is atmospheric, the bellville spring diaphragm 134 is in the position shown in figure 3e. As the inlet pressure

increases, the distance D decreases, and the valve(s) begin to close, as in the previous embodiments. Under flow conditions, the bellville spring diaphragm 134 has a spring characteristic as shown in figure 4 between points A and B,which is not as steep as the rest of the curve, the result being that the lateral deflection of the diaphragm is large for small variations in force.

In figure 3f there is shown a diaphragm 136 which includes one or a number of concentric rings or tubes 137 with a flexible attachment 138 therebetween. The flexible attachments 138 act like hinges with low radial stiffness, low bending stiffness and high axial stiffness. The small volume of material in these regions is allowed to operate at high stress. In doing so they attract only a small proportion of the total strain energy applied to the diaphragm. The much larger volume concentric rings operate at a lower stress to reduce the effects of creep, because, due to their relative bulk, they absorb the majority of the total strain energy.

In figure 3g there is shown a diaphragm 135 which includes a number of circular corrugations 144 oriented axially to produce a bellows arrangement, which allows an increased axial movement while maintaining a more constant spring rate. The spindle 20, diaphragm 135 and corrugations 144 may all be made from the same material, such as a plastics material.

As an example, the current size of the Line Pressure Regulator, as described in US 5035260 has 7 parts plus 3 O-rings and is 70 mm long, and an average diameter of 22 mm, forming an envelope volume of 26,610 mm^3. This is obviously too large to be used as an actuator on an aerosol can.

The fluid regulator of the present invention, as shown in figures 1 and 2, includes only 3 or 4 parts and does not use O-rings. In fact, if the housing and nozzle are discounted, the present invention can be made from a single part. The present invention can be reproduced in an envelope volume of 2460 mm^3. More importantly, the reduction of external size of the present invention is by a factor greater than 10, however, due to the features of the present invention the internal valve diameters have only been reduced by a factor of two. This enables the tolerances to remain acceptable for mass production and provides enough working volume for accurate pressure regulation. The reduction in size

of the present invention allows it to be used with an aerosol actuator. Further, the reduction in size has been necessary to reduce the flow rate of the regulator, as it is desirable to have a flow rate of 50-100 ml per minute for aerosol applications, whereas the previous device had a flow rate of 200 -2000 ml per minute.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A fluid regulator including a spring diaphragm.

2. The fluid regulator as claimed in claim 1 having an inlet chamber and an outlet chamber, wherein at least one valve is attached to a spindle and situated adjacent at least one corresponding port in the inlet chamber to restrict flow to the outlet chamber such that there is minimal net force on the valves from the inlet pressure of the fluid.

3. The fluid regulator of claim 2 wherein the diaphragm controls the clearance between the valves and ports by moving in response to changes in the outlet pressure and thereby regulating the flow of fluid from the inlet to the outlet chamber.

4. The fluid regulator according to any of the preceding claims wherein one side of the spring diaphragm is open to the atmosphere and the other side is exposed to the outlet pressure of the regulator.

5. The fluid regulator as claimed in any of claims 1 to 4 wherein the spring diaphragm is sealingly attached to a housing of the regulator.

6. A fluid regulator having a spring diaphragm, support member and valve of unitary construction.

7. A fluid regulator having a diaphragm which is not subject to a biasing force when no fluid is flowing.

8. The diaphragm as claimed in any of the above claims wherein the diaphragm is constructed from the same material as the valves and spindle.

9. The diaphragm as claimed in any of the above claims wherein the diaphragm is made from a plastics material.

10. A spring diaphragm in the form of a membrane.

11. The spring diaphragm of claim 10 where the membrane is in the form of a plate.

12. The diaphragm as claimed in claim 10 or 11 having at least one weakened portion.

13. The diaphragm as claimed in any of the above claims wherein the weakened portion includes at least one annular groove or area of reduced thickness.

14. The diaphragm as claimed in any of the above claims having a number of radial grooves or areas of reduced thickness.

15. The diaphragm as claimed in any of the above claims having a rippled surface.

16. A fluid regulator as hereinbefore described in the specification.

17. A diaphragm as shown in the accompanying diagrams.

18. A fluid regulator as shown in the accompanying diagrams.

19. The diaphragm of any one of the preceding claims wherein a collar for attaching the diaphragm to the regulator is spaced laterally from the diaphragm.

DATED THIS 9th day of April, 1998

GLENBORDEN PTY LTD and SUNICOVE PTY LTD

WATERMARK PATENT & TRADEMARK ATTORNEYS
290 BURWOOD ROAD
HAWTHORN VICTORIA 3122
AUSTRALIA

RCS/SJM/SH DOC 18 AU002547.WPC

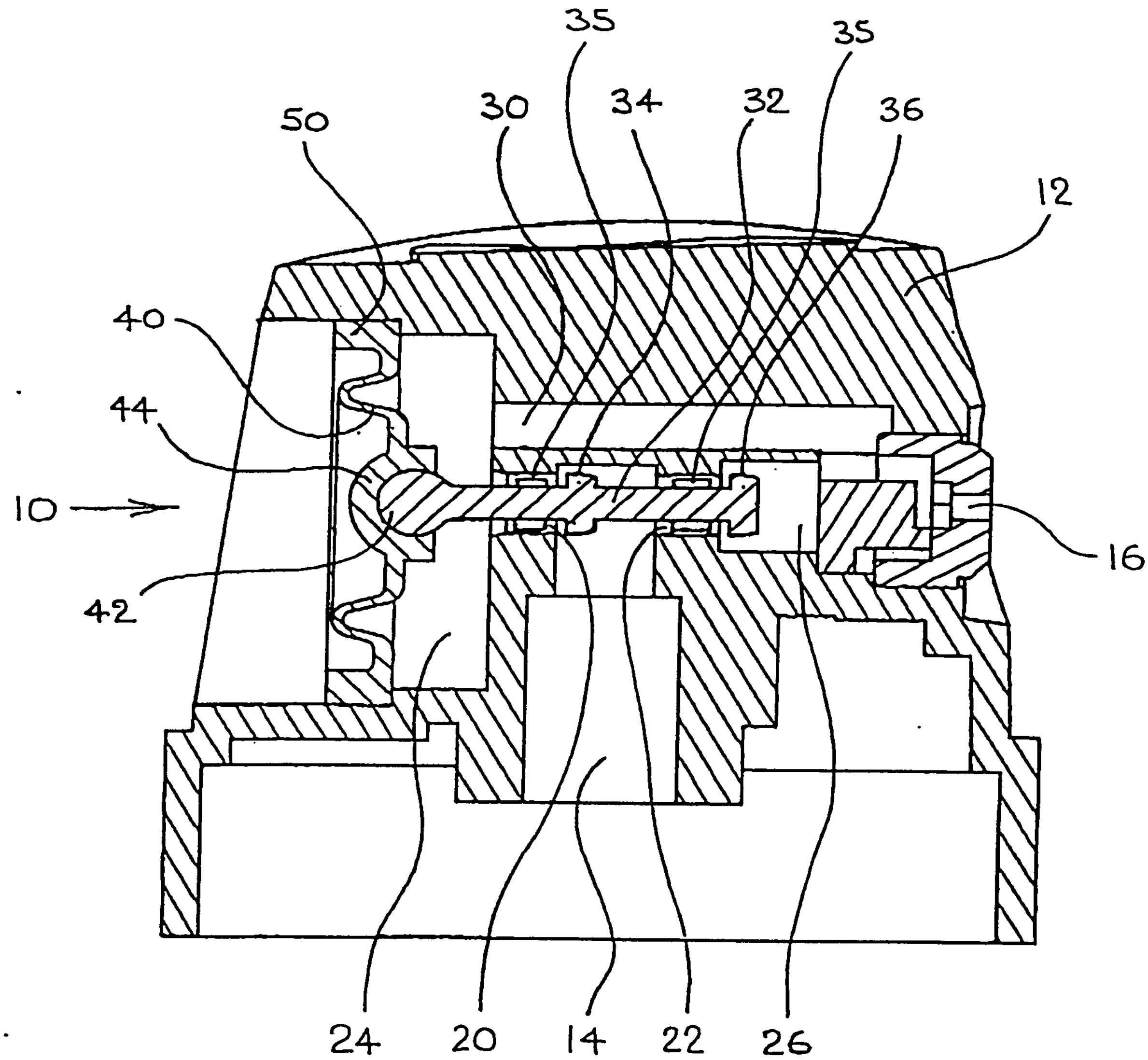


Figure 1

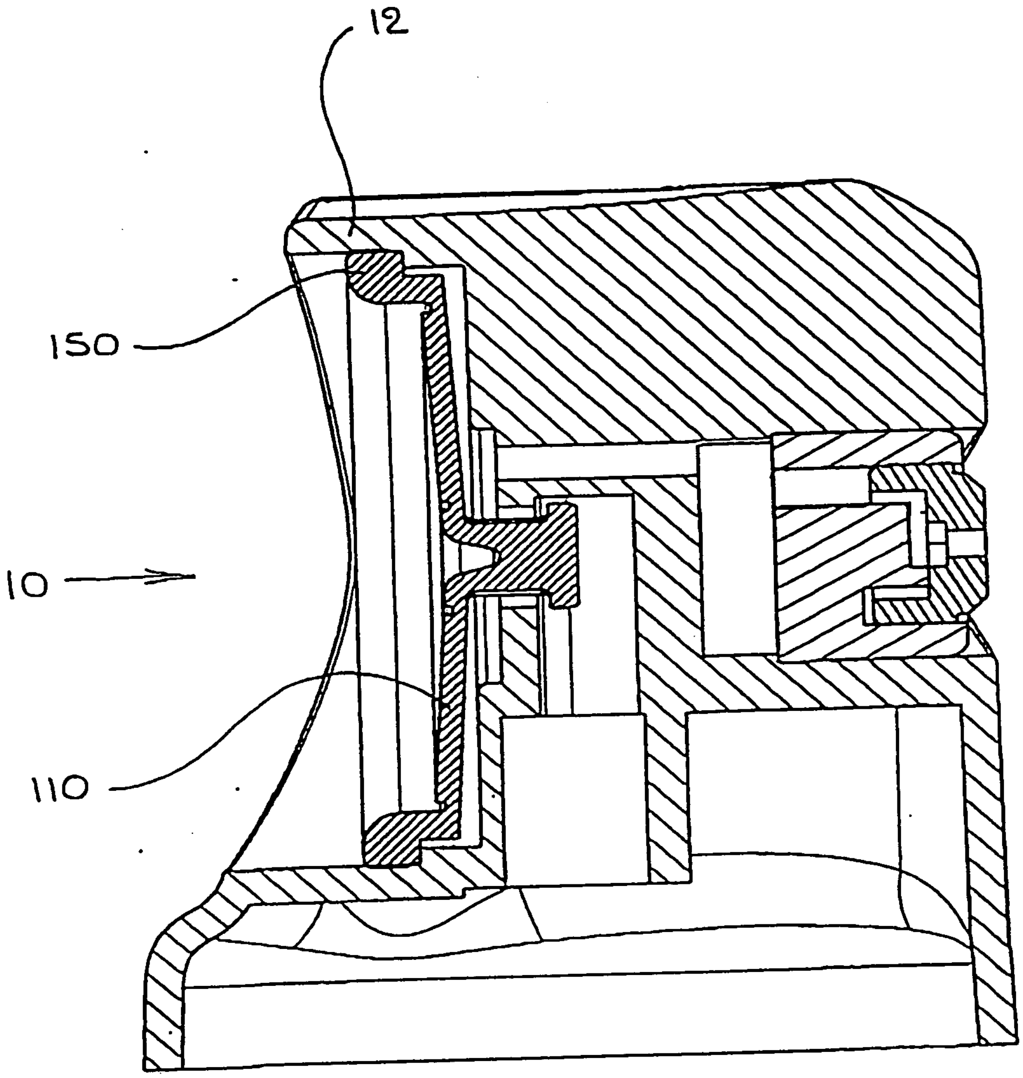


Figure 2

Fig 3a

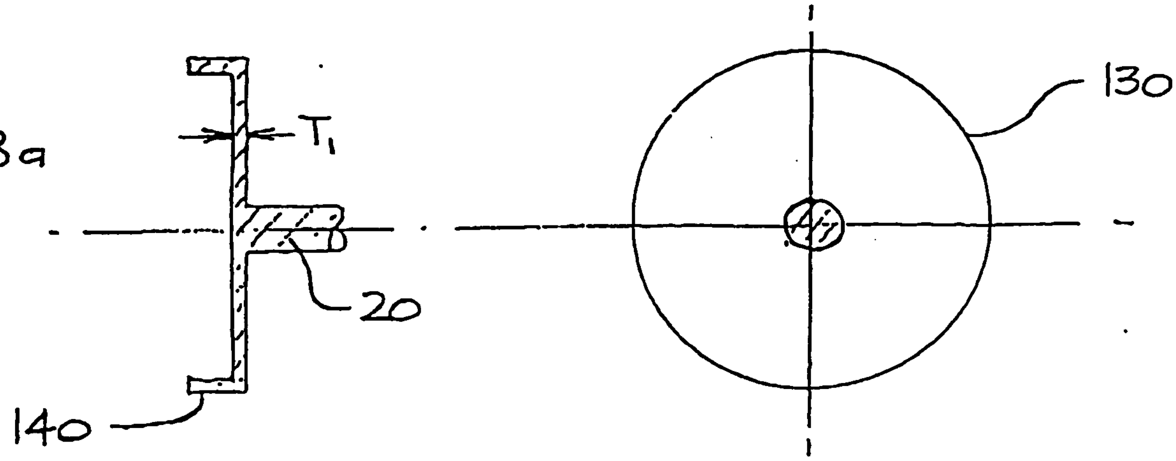


Fig 3b

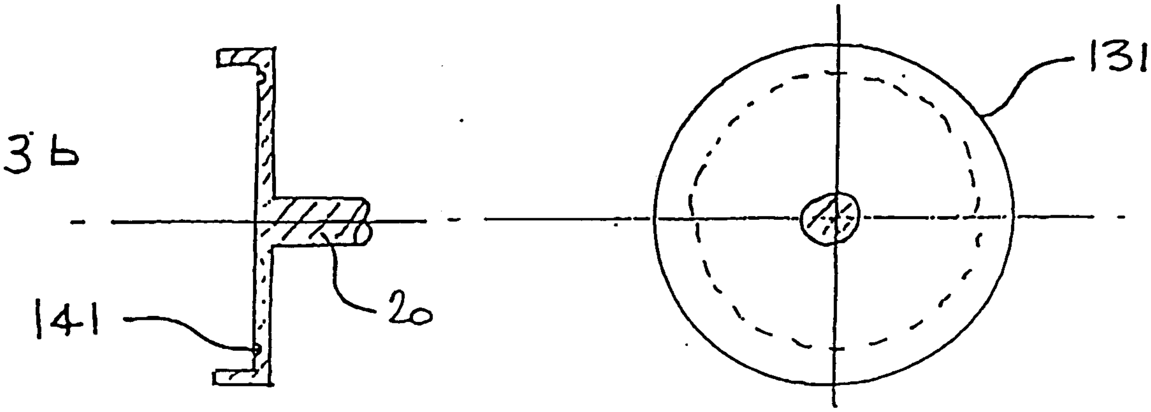


Fig 3c

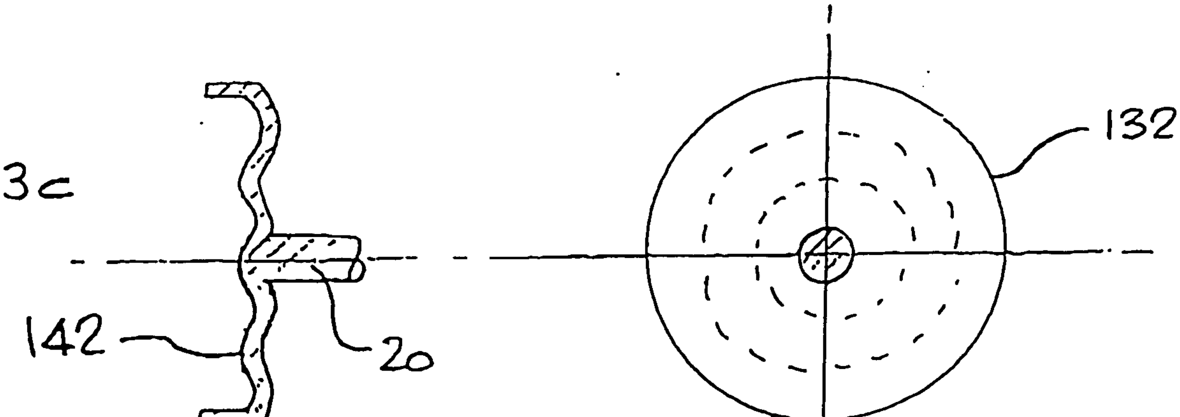


Fig 3d

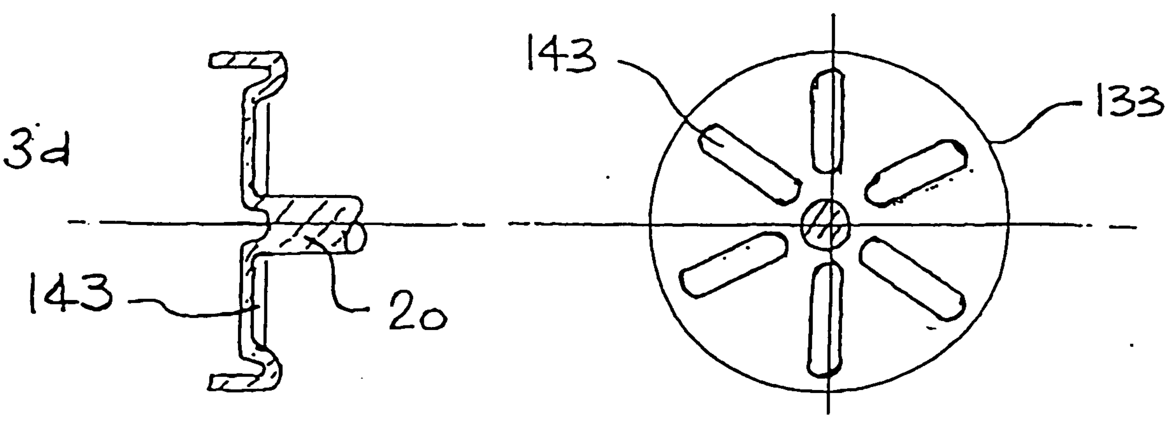
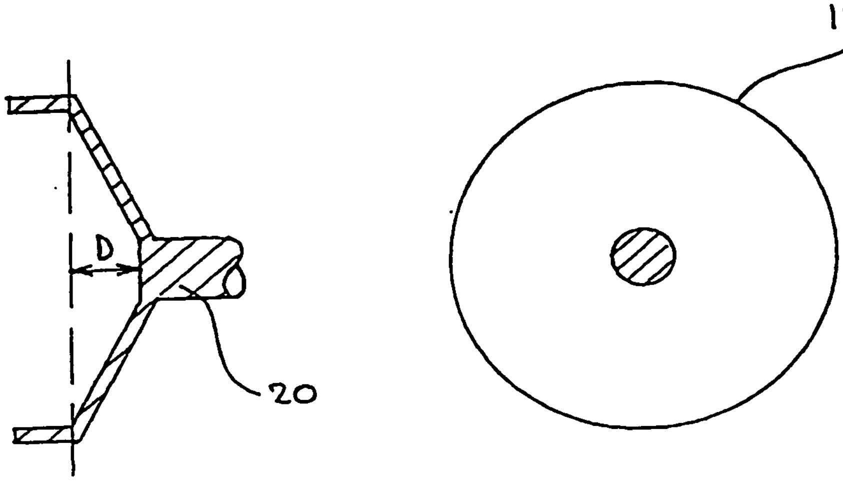


Fig 3e



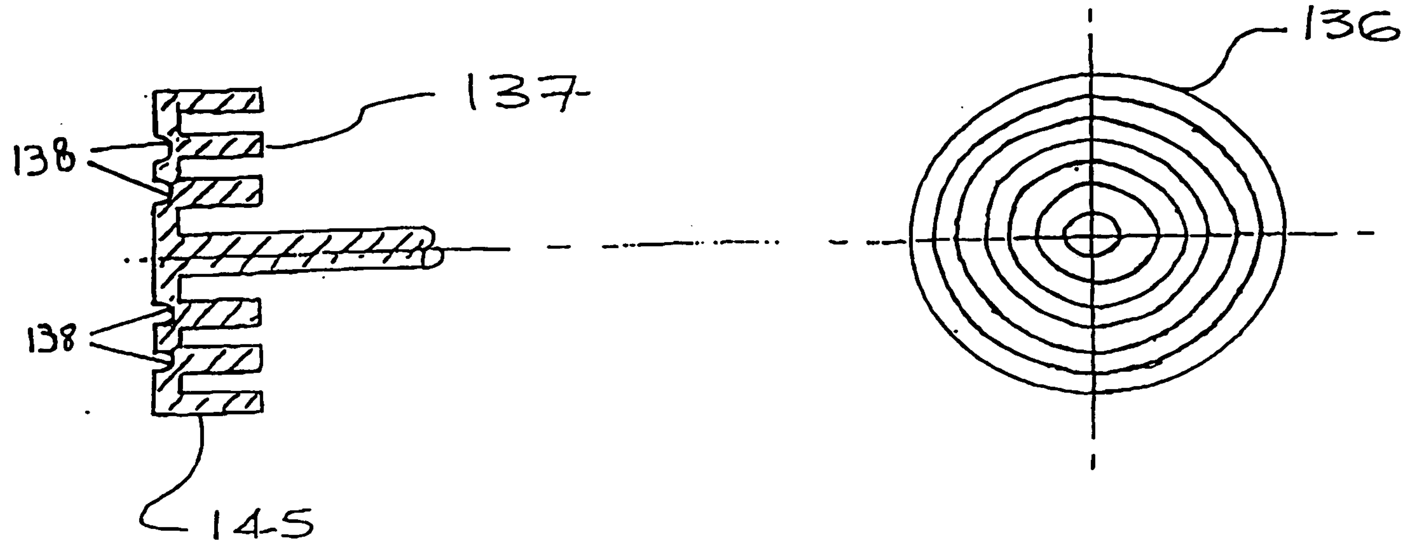


Fig 3f

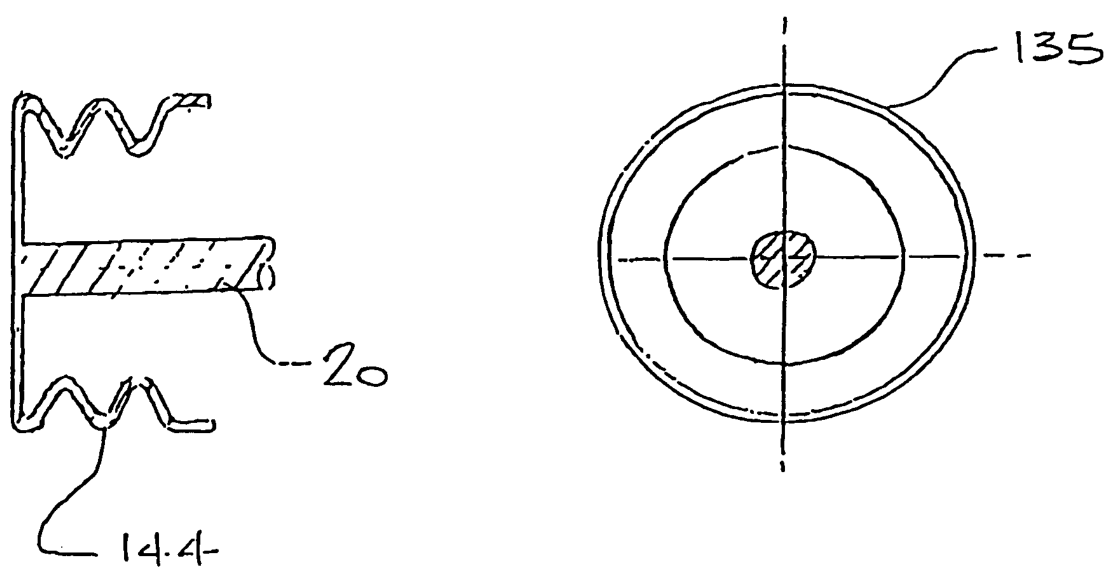


Fig 3g

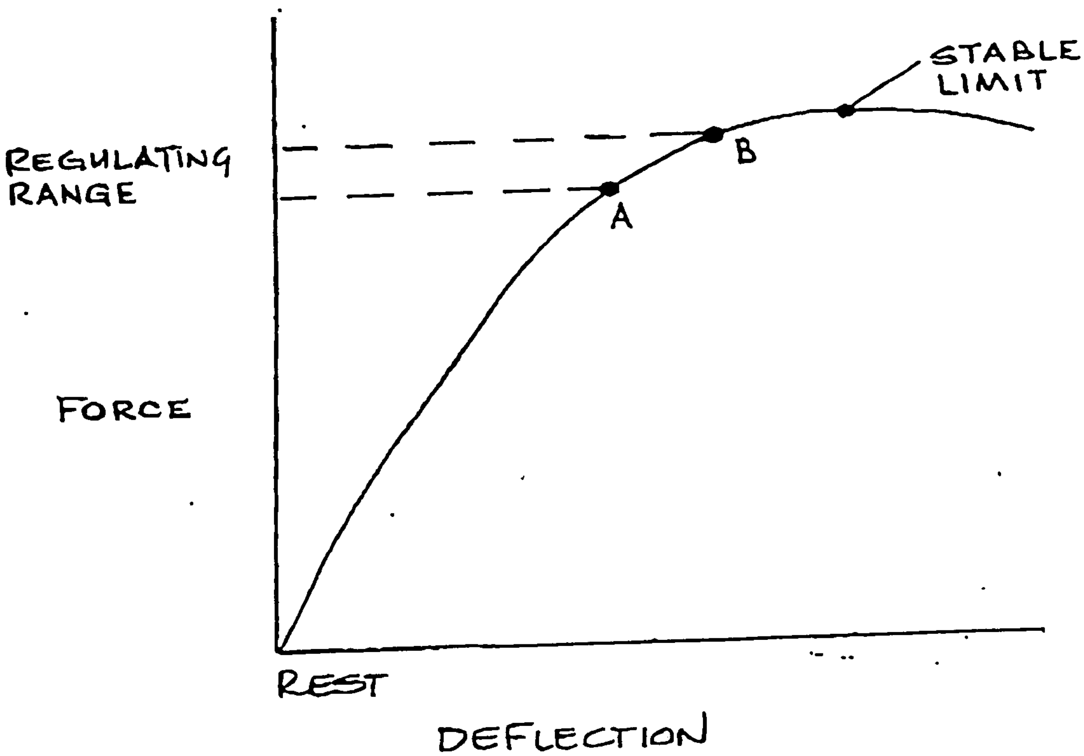


Fig 4